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ENGINE

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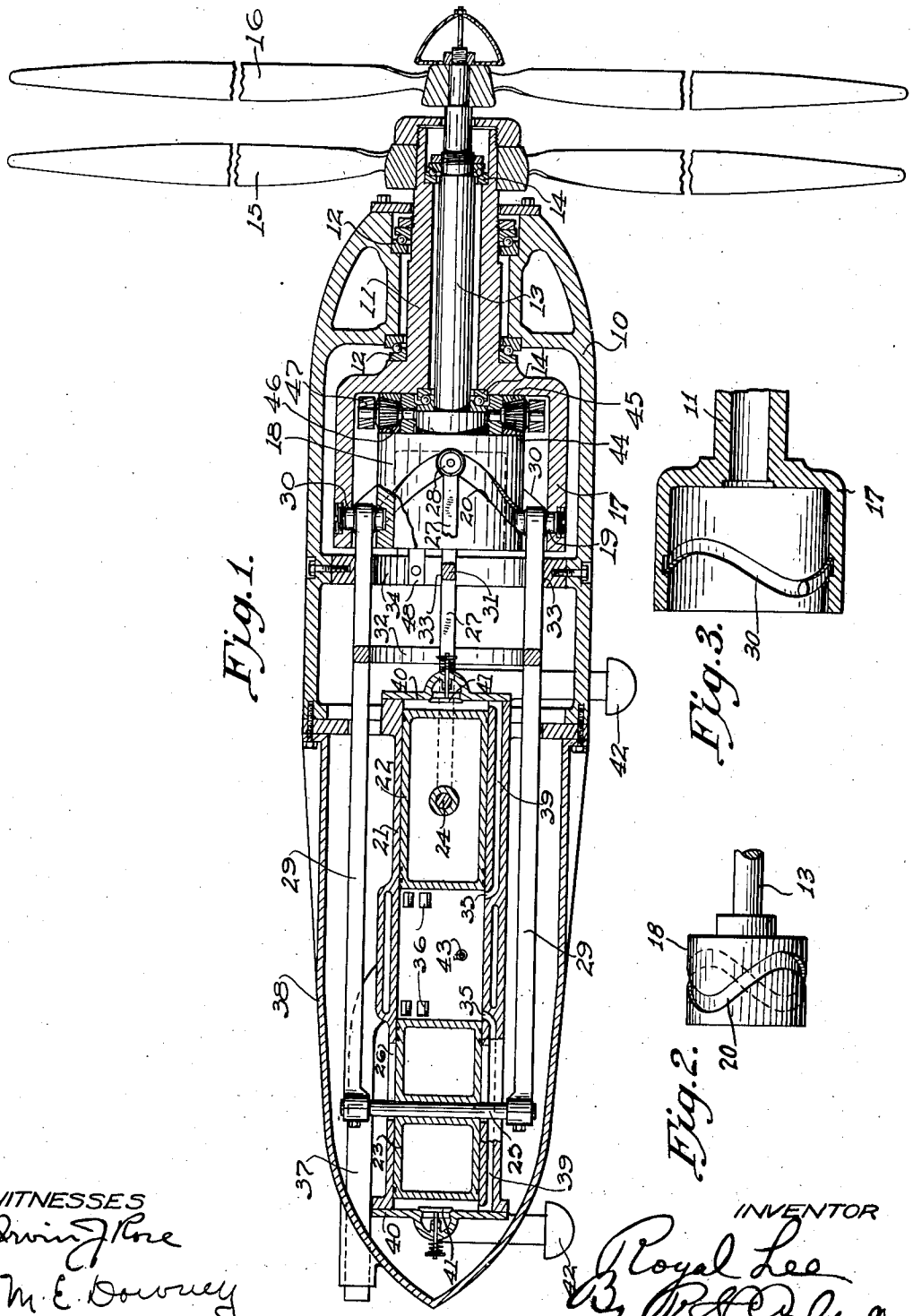


Fig. 1.

Fig. 3.

Fig. 2.

WITNESSES

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ENGINE

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The invention relates to engines, and more particularly to engines adapted for the driving of propellers.

An object of the invention is to provide an engine including a rotary power shaft and a piston-receiving power cylinder therefor which is arranged longitudinally of the shaft, whereby to reduce the radial dimensions of the engine in order to facilitate stream-lining and to expedite the mounting of the engine on narrow bodies such as aeroplane fuselages and wings.

Another object is to provide an engine of this type in which the shaft speed is a submultiple of the piston frequency.

A further object of the invention is to provide an engine including co-axial driving shafts which rotate in opposite directions to neutralize torque effects and to minimize gyroscopic effects.

A further object is t provide driving means for the shafts including a pair of reciprocable pistons moving in opposite directions.

A further object is to provide an engine of this type including cam means for effecting the opposite rotation of the shafts.

The invention further consists in the several features hereinafter set forth and more particularly defined by the annexed claims.

In the accompanying drawing, Fig. 1 is a longitudinal sectional elevation of an engine embodying the invention;

Fig. 2 is a detail view of an inner cam drum forming part of the engine, and

Fig. 3 is a sectional detail view of an outer cam drum forming part of the engine.

In this drawing, the numeral 10 designates a tubular casing in which a hollow shaft 11 is journalled by means of bearings 12 adapted to take both radial and axial thrust. A shaft 13 is disposed co-axially within the hollow shaft 11 and is journalled therein by means of bearings 14 adapted to take both radial and axial thrust. The shafts 11 and 13 project beyond the end of the casing 10, and the inner shaft 13 also projects beyond the end of the outer shaft 11. A propeller 15 is fixedly secured to the outer shaft 11, and a propeller 16 is fixedly secured to the inner shaft 13, the propellers 15 and 16 being arranged in tandem relation. In the present instance, the propellers 15 and 16 are indicated to be air screws.

A cylindrical cam drum 17 is mounted on the inner end of the hollow shaft 11 and a similar but smaller cam drum 18 within the cam drum 17 is mounted on the shaft 13. The cam drums 17 and 18 are provided respectively in their adjacent surfaces with cam grooves or channels 19 and 20 of substantially sinusoidal shape and having the same amplitude, there being two pairs of vertices in each groove.

An engine cylinder 21 is arranged co-axially of the concentric shafts 11 and 13 and in spaced relation to the cam drums, the cylinder including an outwardly flanged portion which is rigidly secured to the casing 10. A pair of pistons 22 and 23 are slidably mounted in the cylinder 21 for reciprocation in opposite directions and are provided with respective piston pins 24 and 25 extending through slots 26 in the cylinder walls. The piston pin 24 is secured at its end portions to a pair of connecting rods 27 arranged in parallel relation to the axis of the cylinder and having their forward portions extending between the cam drums 17 and 18 where they are each provided with aligned rollers 28 entering the cam grooves 19 and 20 in the cam drums to engage the side walls of these grooves. The piston pin 25 is similarly secured at its end portions to a pair of connecting rods 29 arranged in parallel relation to the axis of the cylinder and having their forward portions extending between the cam drums 17 and 18 where they are each provided with rollers 30 entering the cam grooves 19 and 20 in the cam drums to engage the side walls of these grooves. The piston pins 24 and 25 are arranged at right-angles to each other and the connecting rods 27 and 29 are correspondingly arranged in planes at right-angles to each other, the rollers 28 and 30 on the connecting rods being spaced 90° apart on the cam drums. The connecting rods 27 may be rigidly connected together, as by means of a cross bar 31, and the connecting rods 29 may be also rigidly connected together as by means of a ring-

shaped bar 32 which passes outside of the connecting rods 27 in order to reduce the length of the connecting rods. The connecting rods 27 and 29 are guided against lateral displacement by slidably fitting in guide grooves 33 formed in a guide member 34 arranged near the rear edges of the cam drums.

The pistons may be reciprocated by any elastic fluid but preferably form part of an internal combustion engine of the two-cycle type. In the present instance, the cylinder is provided with axially-spaced sets of intake ports 35 and exhaust ports 36 which are respectively uncovered by the pistons at the ends of their power strokes. The exhaust ports 36 are connected with an exhaust pipe 37 which passes through a casing member 38 surrounding the cylinder. A pre-compressed charge of a combustible mixture or air is introduced into the combustion chamber through the intake ports 35, which are connected by by-pass ports 39 with pre-compression chambers at the opposite outer ends of the cylinder. Cylinder heads 40 are secured to the outer ends of the cylinder and each includes a suction-responsive intake valve 41 which, in the case of a carbureting engine, is connected to a carbureting device 42. In the case of a fuel injection type of engine, the pre-compressed charge will consist of air. The combustible mixture present in the combustion chamber may be ignited by a suitable ignition device 43, or by means of the heat of compression.

The concentric shafts 11 and 13 are rotatable in opposite directions, and in order to insure such opposite rotation, especially on starting, it is desirable to provide some equalizing or synchronizing means operatively connected to the shafts. Such equalizing or synchronizing means may assume various forms and in the present instance is shown to consist of a plurality of bevel pinions 44 meshing with bevel gears 45 and 46 respectively secured to the outer and inner cam drums 17 and 18, the pinions being rotatably mounted on a stationary carrier 47 which includes rearwardly projecting arms 48 passing through the space between the drums and secured to some stationary part of the engine, such as the guide member 34.

In operation, the pistons 22 and 23 are reciprocated in opposite directions in the cylinder 21. In the movement of the pistons away from each other, a charge is compressed in the opposite outer end portions of the cylinders, and as soon as the intake ports 35 are uncovered by the pistons, the charge flows through the by-pass ports 39 and into the combustion chamber between the pistons. This charge is compressed by the pistons on their inward strokes, and simultaneously fresh charges are drawn into the pre-compression chambers. At the end of the compression stroke, the compressed charge between the now closely adjacent pistons is ignited, whereupon the pistons move outwardly in opposite directions on power strokes, at the conclusion of which the spent gases are discharged through the exhaust ports 36 and outwardly through the exhaust pipe 37. The fresh pre-compressed charge which is introduced through the ports 35 serves to scavenge the cylinder, and the cycle of operation is then repeated. The connecting rods 27 and 29, which are reciprocated by the pistons 22 and 23, effect the rotation of the cam drums 17 and 18 by the action of the rollers 28 and 30 on the side walls of the cam grooves 19 and 20, thus rotating the propellers 15 and 16 at the same speed but in opposite directions. The rotation of the propellers in the surrounding fluid medium serves to effect the propulsion of the craft on which the engine is mounted.

Since the engine is of the two-cycle type, the rollers 28 and 30 have a tendency to remain in continuous engagement with the same sides of the cam grooves, thus minimizing lost motion. The reciprocating masses are preferably balanced to minimize vibration, and the rotating masses are also preferably balanced for the same reason and for the further purpose of minimizing gyroscopic effects. The side thrust on the roller-carrying ends of the connecting rods is relatively low, since the lateral component of pressure on one of the rollers will be substantially balanced out by an oppositely-directed lateral component of pressure on the companion roller. The tooth pressures on the equalizing pinions 44 are relatively light since the load reactions on the two oppositely-rotating propellers are substantially the same. In some instances, it may be necessary to make the propellers of different length or pitch in order to divide the load equally between the two tandem propellers. By the use of two oppositely-rotating propellers, the torque on the engine casing, and consequently the torque on the craft on which the engine is mounted is cancelled out or minimized. The disposition of the power cylinder axially of the propeller shafts permits the diameter of the engine casing to be materially reduced, thereby facilitating stream-lining either of the engine casing or of the support on which the engine is mounted.

What I claim as new and desire to secure by Letters Patent is:

1. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, power means including a cylinder and a piston relatively reciprocatory therein, and cam means operatively connected with said power means for rotating said co-axial shafts in opposite directions.

2. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, a cam drum on each shaft each having

a sinuous cam surface, a cylinder arranged coaxially of said shaft, a piston in said cylinder, and means operatively connecting said piston and the cam surfaces of both of said drums for rotating said shafts in opposite directions.

3. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, cam drums on said respective shafts arranged one within the other and each having a sinuous cam surface, a cylinder arranged in parallel relation to said shaft, a reciprocatory piston mounted in said cylinder, and means operatively connecting said piston with the cam surfaces of both of said cam drums for rotating said shafts in opposite directions.

4. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, a pair of cam drums respectively secured to said shafts and each having a sinuous cam surface presenting a plurality of pairs of crests, and power means including a reciprocatory piston having an operative connection with the cam surfaces of said drums for rotating said shafts at a speed which is a submultiple of the piston frequency.

5. In an engine, the combination of a pair of co-axial shafts arranged one within the other and rotatable in opposite directions, a pair of cam drums respectively secured to said shafts, power means including a cylinder and a reciprocatory piston therein, and means operatively connecting said piston with said cam drums for rotating said shafts in opposite directions.

6. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, power means including a cylinder and a piston therein for rotating said shafts at the same speed but in opposite directions, and synchronizing means distinct from the power means for insuring the opposite rotation of said shafts at the same speed.

7. In an engine, the combination of a rotatable shaft, a cylinder extending co-axially of said shaft, a pair of pistons mounted in said cylinder for reciprocation in opposite directions, said cylinder and shaft being arranged in tandem relation, a pair of actuating members respectively secured in said pistons and each projecting laterally therefrom in opposite directions, and connecting rods secured to the laterally projecting portions of said actuating members and having operative connections with said shaft at angularly spaced points thereof.

8. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, a pair of cam drums respectively mounted on said shafts and each having a sinuous cam surface each presenting a plurality of pairs of crests, a cylinder arranged co-axially of said shafts, a pair of pistons mounted in said cylinders for reciprocation in opposite directions, a pair of actuating members for said respective pistons projecting laterally from said pistons at opposite sides thereof and arranged in different radial planes, a pair of connecting rods for each piston secured to the projecting portions of the actuating member and each pair of connecting rods having an operative connection with the cam surface of the cam drum at diametrically opposite portions of said drum, the operative connections of one pair of said connecting rods with said cam drum being angularly spaced from the operative connections of the other pair of connecting rods with said cam drum.

9. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, a power cylinder arranged in co-axial relation to said shafts, a pair of opposed reciprocatory postons mounted in said cylinder, and means operatively connecting said pistons and said rotary shafts.

10. In an engine, the combination of a pair of co-axial shafts rotatable in opposite directions, a power cylinder arranged in co-axial relation to said shafts, a pair of opposed reciprocatory pistons mounted in said cylinder, and means operatively connecting each of said pistons with both of said shafts for rotating said shafts in opposite directions.

11. In an engine, the combination of a rotatable shaft, a cylinder arranged co-axially of said shaft, a pair of opposed pistons in said cylinder, wrist pins for said pistons projecting laterally from opposite sides thereof, the wrist pin in one piston being disposed in a different plane from the wrist pin in the other piston, and pairs of connecting rods operatively connecting said wrist pins and said shaft and disposed in the respective planes of said wrist pins.

12. In an engine, the combination of a rotatable shaft, a cylinder arranged co-axially of said shaft, a pair of opposed pistons in said cylinder, wrist pins for said pistons projecting laterally therefrom, the wrist pin in one piston being disposed in a different plane from the wrist pin in the other piston, and means operatively connecting said wrist pins with said shaft.

In testimony whereof, I affix my signature.

ROYAL LEE.